# NATIONAL BUREAU OF STANDARDS REPORT

5464

Stress Corrosion of Stainless Steel



Progress Report

Year Ending September 30, 1957

by

Hugh L. Logan

To

Pressure Vessel Research Committee

of the

Welding Research Council

NBS

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

# THE NATIONAL BUREAU OF STANDARDS

## Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

## Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C.

Inquiries regarding the Bureau's reports should be addressed to the Office of Technical Information, National Bureau of Standards, Washington 25, D. C.

# NATIONAL BUREAU OF STANDARDS REPORT

**NBS PROJECT** 0804-10-4124

September 20, 1957

**NBS REPORT** 5464

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Year Ending September 30, 1957

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Pressure Vessel Research Committee

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NATIONAL BUREAU OF STANDARDS

Progress Report

Report to PVRC

for

Year Ending September 30, 1957

on

Project 4124

Stress Corrosion of Stainless Steel

Sponsored by

Pressure Vessel Research Committee

The results obtained from January 1, 1956 to date on this project are being summarized in a paper prepared for the Welding Journal and for possible presentation at the 1958 meeting of the American Welding Society. Results of the investigation were also presented by invitation at the Gordon Research Conference on Corrosion, New London, New Hampshire on July 19.

In the early work, stress-corrosion cracking was produced in the types 304 and 304L stainless steels by stressing them to approximately their room temperature yield strengths in a boiling solution containing 3-1/2 percent NaCl and 1 percent commercial $NH_4NO_2$. It was difficult to obtain $NH_4NO_2$ commercially and that product, when obtained, contained certain impurities. After some experimentation a solution containing NaCl + $NH_4Cl$ + $NaNO_2$ was found to produce satisfactory results. Figure 1 shows the tensile properties of groups of specimens removed from this corrodent after various exposure periods and subsequently broken in the tensile test. It is seen that the percent elongation and ultimate tensile strength decrease in a consistent manner with increased exposure periods. The average number of stress corrosion cracks developed, per specimen, reached a maximum for specimens exposed for a 4 hour period and did not change appreciably with increased exposure periods. Figure 1 also shows the decrease in concentration of the nitrite ion, in the solution, with increased exposure periods. It was determined by mass spectrographic methods that the amount of nitrogen given off with the gaseous products of the corrosive action increased with the exposure period. No oxides of nitrogen were found in this product. From these data it was concluded that ammonium nitrite was being formed by the double decomposition of the ammonium chloride and the sodium nitrite and that

The possibility that the hydrolysis of the chloride corrosion products of stainless steel may produce further chemical attack of the steel has been investigated. The corrodibility of types 304 and 304L stainless steels in the boiling solutions listed in Table 1 was determined by visual examination. Corrosion of the steel occurred in the $FeCl_3$ solutions having pH values less than 5 and in the $FeCl_2$ + HCl solution with a pH of 1.3. The steels were locally pitted in these solutions with little or no general attack and much of the exposed area showing no evidence of attack at all. If the specimen was made the anode in an electric circuit with an externally applied current, it was pitted in all of the solutions listed in Table 1 and also in the boiling NaCl + $NaNO_2$ solution currently being used as a corrodent. The anode specimen and the cathode were placed in separate compartments, connected through a semipermeable membrane. Under these conditions, the solution in the anode compartment became more acid as the exposure period was increased.

A specimen stressed to its room temperature yield strength and made the anode in the boiling NaCl + $NaNO_2$ solution, with the current density 0.1 $ma/cm^2$, developed stress corrosion cracks and failed in less than 24 hours. Conversely, a specimen made the cathode but subjected to the same stress and current density did not develop stress-corrosion cracks in a 48 hour exposure period.

The technique for treating specimens so as to obtain crystals 1/16 inch or more, in diameter in the reduced section, has been improved and a relatively high yield of specimens of this kind has been obtained for crystallographic studies. As has been reported previously, however, it is much more difficult to produce stress corrosion cracking in specimens having a very large grain size than in those having the normal grain size.

Time lapse photographic studies of the stress-corrosion cracking process are continuing. Specimens are eccentrically stressed, in the special cell described in earlier reports, so that most stress-corrosion cracks develop on the surface facing the camera. The current problem is to obtain greater resolution and hence a higher possible magnification. Increasing the resolution, of necessity, reduces the size of the field that can be photographed and hence decreases the probability of photographing a stress-corrosion crack.

Expenditures of Pressure Vessel Research Committee funds for the period ending September 30, 1957 are estimated to be:

| | |
|---|---|
| Salaries | $5800 |
| Other Objects | 2100 |
| NBS Supervision and Services | 1770 |
| Total | $9670 |

Respectfully Submitted

Hugh L. Logan

Hugh L. Logan
Physicist

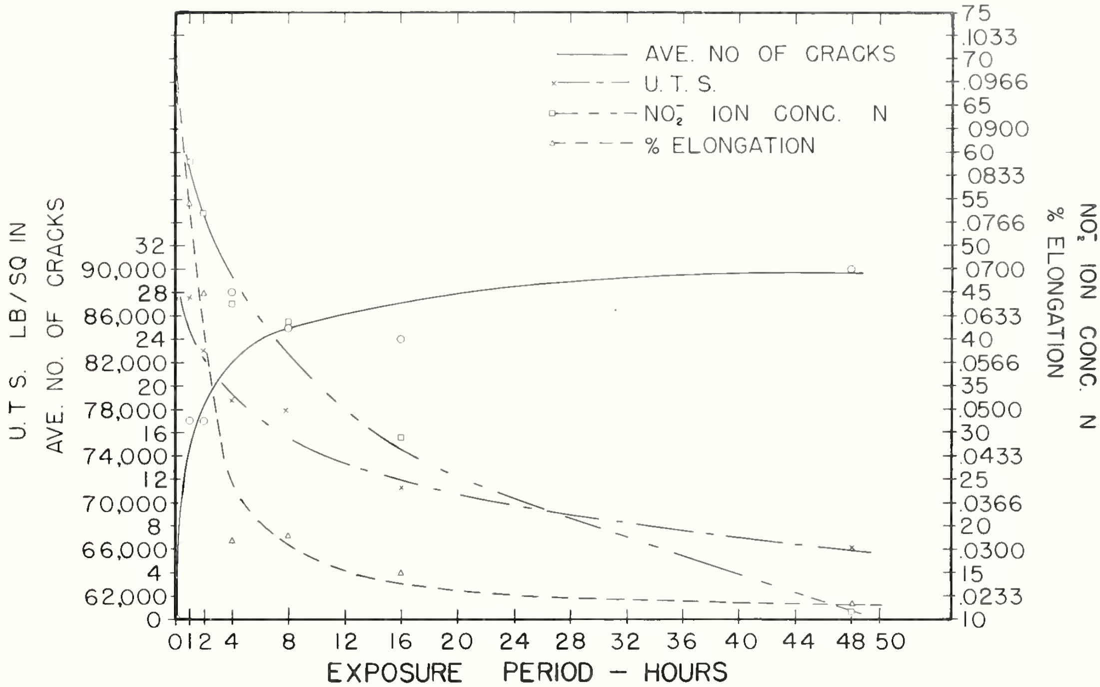


Fig. 1 Relationship omong the average number of cracks formed, ultimate tensile strength, concentration of the $NO_2^-$ ion percent elongation ond the exposure period of type 304 stainless steel specimen in a bailing .5 normal NaCl, .1 normal $NH_4Cl$, .1 normal $NaNO_2$ salution.

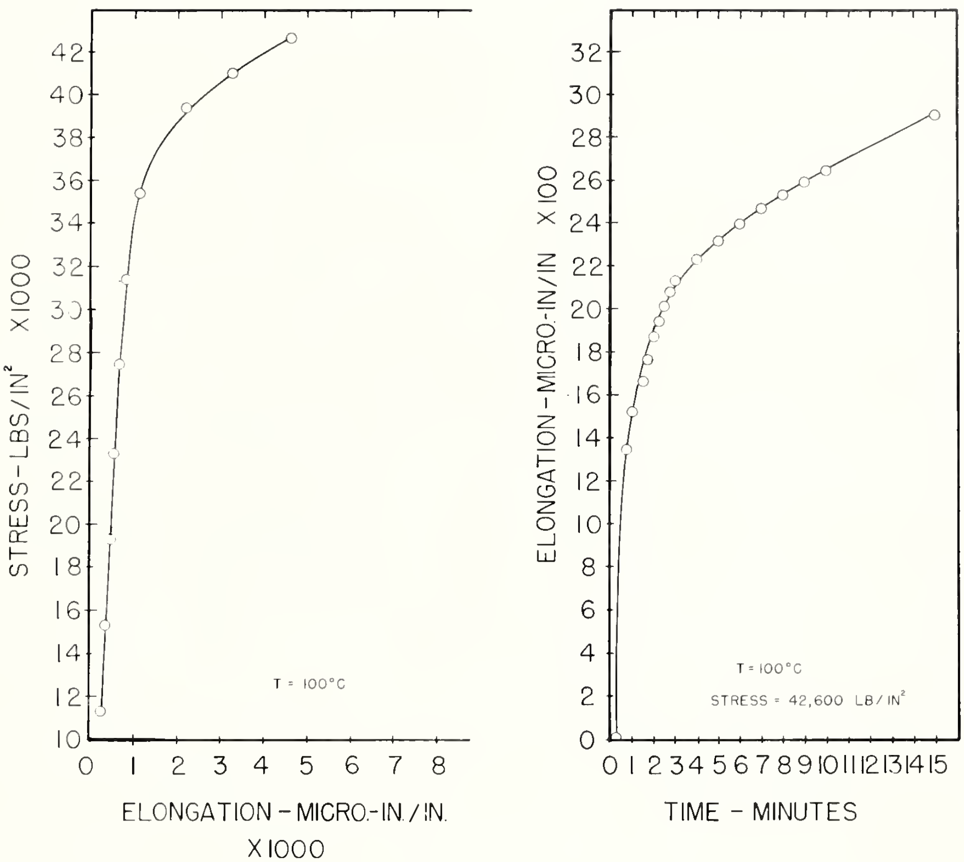


Fig 2 Left, stress-strain curve for transverse specimen of type 304 stainless steel immersed in boiling distilled water. Right, stroin-time curve for specimen at constant stress in boiling distilled $H_2O$.

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

# THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major field laboratories in Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside front cover of this report.

## WASHINGTON, D. C.

**Electricity and Electronics.** Resistance and Reactance. Electron Tubes. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

**Optics and Metrology.** Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

**Heat and Power.** Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology and Lubrication. Engine Fuels.

**Atomic and Radiation Physics.** Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

**Chemistry.** Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

**Mechanics.** Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

**Organic and Fibrous Materials.** Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

**Metallurgy.** Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

**Mineral Products.** Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

**Building Technology.** Structural Engineering. Fire Protection. Heating and Air Conditioning. Floor, Roof, and Wall Coverings. Codes and Specifications.

**Applied Mathematics.** Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

**Data Processing Systems.** SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analogue Systems. Application Engineering.

- Office of Basic Instrumentation
- Office of Weights and Measures

## BOULDER, COLORADO

**Cryogenic Engineering.** Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

**Radio Propagation Physics.** Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships.

**Radio Propagation Engineering.** Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering.

**Radio Standards.** Radio Frequencies. Microwave Frequencies. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.

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